ation must accordingly be granted, and based on CTP's "written showing," CTP's request for Pioneer's Preference must be granted.

II. THE COMMISSION'S CONCLUSION THAT ISCDMA LACKS INNOVATIVENESS IS UNSUPPORTED BY THE RECORD AND FACTUALLY INCORRECT.

The Commission concludes that:

> [P]roposed ISCDMA is a compilation of CT-2 Plus concepts and Qualcomm's equipment and lacks innovativeness.[54]

The truth is:

- It was precisely to avoid CT-2 and CT-2 concepts that ISCDMA was invented. As pointed out above, CTP conveyed EasyPhone to BCE because the PCI technology, co-invented by CTP, required a CT-2 platform. CTP had become convinced by 1991 that CT-2 is not a good technology platform for mass market PCS in the U.S. at 1850-1990 MHz, and therefore created ISCDMA.

- ISCDMA contains no CT-2 Plus concepts but rather takes advantage of frequency agility and dynamic channel allocation found in CT-2, Qualcomm CDMA and many other PCS technologies. The central technology of ISCDMA is a set of proprietary algorithms which are not found in CT-2 or CT-2 Plus. ISCDMA is based on FDD whereas ISCDMA is based on TDD. ISCDMA has capabilities to deal with non-standard microwave offset and receive-only microwave transmission (which CT-2 doesn't). ISCDMA works not only on CDMA but also on most other PCS technologies. PCI doesn't. Most important, <u>CT-2 Plus is the only PCS technology on which CTP's Interference Sensing technology does not work!</u>[55] Additionally, CT-2 Plus is defined by the Commission as CT-2 with the "addition of a pager."

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[54]Order, paragraph 209.

[55]CTP has referred to technology, now called CT-3, as verifying that frequency agility and dynamic channel allocation can work to avoid interference. But CTP could equally have refereed to Qualcomm CDMA and several other wireless technologies which similarly demonstrate the workability of frequency agility and dynamic channel allocation to avoid interference. More important, APC started its experimentation with CT-2 and moved to FAST, and FAST embodies similar frequency agility and dynamic channel allocation to CT-2. The Commission has not disqualified APC because its FAST technology embodies concepts found in CT-2. It should not employ a double standard and disqualify CTP. ISCDMA has even less commonality with CT-2 than does FAST because ISCDMA is purely algorithm based.

ISCDMA has never involved a pager, and the PCI technology sold to BCE by CTP also did not involve CT-2 with a pager.[56]

- The Commission states with regard to the FAST technology of the APC/ Washington Post:

  > [T]he integration of CT-2 elements such as the call set-up procedure utilized by APC does not detract from this technology [*i.e.* FAST]; it is only one part of APC's complete system.[57]

  A different standard is clearly being applied by the Commission when it denies CTP a Pioneer's Preference on the basis ISCDMA contains "CT-2 Plus concepts."

- The record shows that ISCDMA is not dependent on Qualcomm's equipment but can be used with most other PCS equipment (with the exception of CT-2 or CT-2 Plus equipment). The reason is that ISCDMA is a set of highly sophisticated algorithms which determine under what conditions a channel is useable (on call set-up) or becomes useable (during the course of a call). As long as the particular equipment used for PCS provides frequency agility and dynamic channel allocation, the CTP algorithms can be employed to determine clear channels on the equipment at call set-up, and to instruct the equipment during a call when to switch channels to avoid interference, (using the frequency agility/dynamic channel allocation capabilities of the equipment). Thus, as the record repeatedly shows, CTP's algorithms will work with TDMA and FDMA equipment, as well as CDMA equipment.

  CTP's specific proposal to the Commission, ISCDMA, was based on Qualcomm's equipment as CTP felt after much study that Qualcomm CDMA has distinct advantages for PCS and would probably be chosen by most operators for PCS. Similarly, FAST is being applied by APC/Washington Post to Qualcomm equipment.[58] APC is not being disqualified for applying FAST to Qualcomm equipment. Indeed the Commission cites with favor in the Order that FAST is using Qualcomm equipment and the particular capabilities of this equipment, such as FAST's use of Qualcomm CDMA pilot channels

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[56]Order, page 70, footnote 231.

[57]Order, paragraph 11.

[58]FAST is like ISCDMA in that it can be applied to many different types of PCS equipment.

for frequency sharing.[59] A double standard is being applied by the Commission in determining that CTP "lacks innovativeness" because CTP has opted to use Qualcomm equipment.

- There is nothing in the record to support the Commission's conclusion that ISCDMA "lacks innovativeness." No applicant has attacked ISCDMA as lacking in innovativeness.[60] No applicant has been able to cite any prior work from which CTP's algorithms were derived, or even any similar interference sensing approach.[61] On the other hand, CTP has filed voluminous showing of innovativeness and uniqueness of innovation.[62] Further, CTP filed evidence of its patent application and the patentability of ISCDMA. It is a clear misconception of the record and misapplication of Commission Rules to conclude that ISCDMA, a patentable technology whose uniqueness has not been challenged, "lacks innovativeness."

- The APC/Washington Post FAST approach clearly contains elements of prior work such as the CCIR work detailed in attached Exhibit 3 yet has been found by the Commission to be innovative. CTP's ISCDMA does not have any elements from previous work yet has been found to lack innovativeness. A double standard is being applied.

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[59]Order, paragraph 17. As will be noted from attached Exhibits 1 and 2, CTP used Qualcomm CDMA pilot channels for frequency sharing well before FAST.

[60]To the contrary, the PacTel filing that the Commission cites in paragraph 200 of the Order refers to ISCDMA as a "novel idea."

[61]On the other hand, many applicants have noted that FAST is derived from other technologies.

[62]*E.g.* CTP Reply Comments in this Docket, dated June 25, 1992; CTP's Comments in this Docket, dated January 27, 1993; CTP's Reply Comments in this Docket, dated March 1, 1993.

III. WHILE THE COMMISSION HAS CHANGED ITS LANGUAGE, THE COMMISSION STILL CONTINUES TO DENY CTP'S REQUEST FOR PIONEER'S PREFERENCE BASED ON A DETERMINATION OF RELATIVE TECHNICAL SUPERIORITY, AND THIS IS A LEGALLY IMPERMISSIBLE BASIS FOR DENIAL.

In its Tentative Decision, the Commission denied CTP's Request for Pioneer's Preference because:

> [W]e believe that APC has brought to fruition a superior method of frequency avoidance.[63]

Accordingly, as noted above, CTP filed extensive technical reports and other documents showing ISCDMA is instead superior to FAST; and that under Commission Rules, relative technological superiority is an improper ground for denial of a request for Pioneer's Preference.[64] The Commission cannot without detailed comparative lab testing, and should not under its Rules, be in a position of arbiter of relative technology merit. In the Order the Commission agreed, but only in part, stating:

> We agree with CTP that finding one technology to be superior to another is not a basis for denial of a Pioneer's Preference. However, it does serve as a measure of innovativeness.[65]

In other words, what the Commission has done is to continue to use relative technology superiority as the basis for denial of Pioneer's Preference, but now cloak its determination of relative technology superiority under the guise of a determination of innovativeness. The Commission has really not changed its conclusion; and the conclusion reached by the Commission was without there being any technical evaluation of FAST versus ISCDMA by the Commission, and against the weight of the specific technical evaluations prepared by CTP with TSR and LCC. This is plainly unacceptable. A mockery is made of the Commission Rules requiring innovativeness if relative technology superiority is to be made the basis of determining innovativeness. There is no other explanation of the Commission's reasoning as there is no evidence in the record that ISCDMA "lacks innovativeness" other than the Commission's finding that "APC has brought to fruition a superior method of frequency avoidance." CTP demonstrated in its Comments in this Docket[66] that ISCDMA

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[63]Tentative Decision, paragraph 31.

[64]CTP's Comments in this Docket, dated January 27, 1993.

[65]Order, page 69, footnote 226.

[66]Filed January 27, 1993.

is superior to FAST in cost, capacity, flexibility, regulatory simplicity and exportability. Denial of CTP's request for Pioneer's Preference is thus plainly wrong as a matter of fact, and wrong as a matter of law under the Commission's Rules as a determination of innovativeness is being made based on the Commission's finding of technology superiority. CTP's Petition for Partial Reconsideration must be granted; and based on CTP's repeated demonstrations of innovativeness, CTP must be granted a Pioneer's Preference.

IV. THE COMMISSION'S CONCLUSION THAT CTP's REQUEST FOR A PIONEER'S PREFERENCE SHOULD BE DENIED BECAUSE IT HAS CONVEYED ITS CT-2 INVENTION TO ANOTHER COMPANY APPLIES A DOUBLE STANDARD AND IS BASED ON A MISCONCEPTION OF THE RECORD.

A clear double standard is applied by the Commission in concluding CTP's request for Pioneer's Preference should be denied because CTP sold EasyPhone to BCE together with its "CT-2 invention." According to many reports, the Washington Post Company has purchased and now owns 70% of APC. On all available information, at the time of APC's alleged development of FAST (Spring, 1990) the Washington Post Company did not own a majority of APC. CTP should be treated like APC and should not be denied a Pioneer's Preference because of the sale of EasyPhone to BCE and of CTP's "CT-2 invention".

What the Commission states with regard to the sale of EasyPhone to BCE is that:

> CTP maintains that it is the only applicant that has entirely original PCS technology; however, it also states that its interference sensing concept is well established due to its use in CT-2 and CT-2 Plus operations, and that it has conveyed its ownership in its CT-2 invention to another company.[67]

We have already dealt with the fact that CTP referred to CT-2 and CT-2 Plus only to establish that interference sensing is technically feasible. Frequency agility and dynamic channel allocation are present in CT-2, CT-3, Qualcomm CDMA and a number of other PCS technologies, including FAST. CTP uses its proprietary algorithms to identify clear channels at call set-up and to inaugurate switching to a clear channel during the course of a call upon detecting interference on the channel in use. For this, Interference Sensing takes advantage of the built-in frequency agility/dynamic channel allocation capabilities of the various PCS technologies.[68]

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[67]Order, paragraph 209.

[68]The FAST technology in exactly the same manner takes advantage of the built in frequency agility/ dynamic channel allocation capabilities of the various PCS technologies. The difference is that the "trigger" for channel switching to avoid interference under CTP's Interference Sensing approach is a set of proprietary algorithms whereas in the case of FAST the trigger is a data base of useable channels that has been created

With regard to CTP's conveyance of "its ownership in its CT-2 invention to another company,"[69] we pointed out above that the central element of ISCDMA is its proprietary algorithms and that ISCDMA shares little, if anything, with CT-2 or CT-2 Plus. The conveyance of CTP's "CT-2 invention" in no way affects the ownership, uniqueness or innovativeness of ISCDMA. The FAST approach, based on frequency agility and dynamic channel allocation such as that found in CT-2 is closer to CT-2 and CT-2 Plus than is ISCDMA. Yet the Commission in paragraph 22 of the Order excuses the FAST approach in this regard.

In citing the sale of CTP's CT-2 invention (PCI) the Commission is picking up the allegations of APC/Washington Post in its Reply Comments in this Docket, dated March 1, 1993. These allegations were fully rebutted in CTP's Further Reply Comments dated March 12, 1993. Yet CTP's rebuttal is not cited; only APC's allegations regarding sale of the "CT-2 invention" are cited. Again a double standard is being applied. Accordingly CTP's Petition for Reconsideration should be granted; and based on the record of CTP's innovation, a Pioneer's Preference should be granted to CTP.

V. THERE IS AMPLE EVIDENCE THAT ESSENTIAL ELEMENTS OF FAST DUPLICATED EARLIER WORK OF CTP AND ACCORDINGLY CTP SHOULD BE AWARDED A PIONEER'S PREFERENCE.

In its Tentative Decision the Commission tentatively denied CTP a Pioneer's Preference stating:

> We can find no merit to CTP's arguments that APC's technology is derived from that developed by CTP.[70]

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through theoretical and field propagation measurements.

[69] *Id.*

[70] Tentative Decision, paragraph 31. In paragraph 31 of the Order the Commission changes the basis of its finding that the APC/Washington Post technology "is derived from that developed by CTP." Now the Commission states:

> CTP alleges that there is substantial evidence that essential elements of FAST were derived specifically from CTP's prior Interference Sensing Code Division Multiple Access (ISCDMA) work.

This was not CTP's allegation. Certain elements of FAST may well have been copied from ISCDMA as these elements appeared in FAST after they had been publicly introduced by CTP as part of ISCDMA. This includes use of algorithms (not developed by APC/Washington Post until December, 1992/January, 1993) and most recently use of Qualcomm equipment pilot channels for frequency sharing. However, what CTP principally alleged is that elements of FAST appear to have been derived from CTP's prior work in 1990 on PCI, not ISCDMA.

Accordingly CTP submitted voluminous evidence which, while entirely circumstantial, by its combined weight made it almost impossible to conclude that APC/Washington Post had not taken from CTP's prior work. This is fully set out in CTP's Comments in this Docket.[71] In these Comments CTP showed that the use of frequency agility and dynamic channel allocation, central to FAST, were detailed in filings with the Commission and in materials specifically sent to APC/Washington Post long before APC/Washington Post incorporated these elements in its FAST approach. CTP showed that FAST call set-up procedure and channel monitoring procedure described by the Commission in paragraphs 14 and 15 of the Order are almost identical to the procedures for call set-up and channel monitoring detail in materials sent by CTP to APC/Washington Post more than a year before APC/Washington Post announced its call set-up and channel monitoring procedures. CTP showed that APC/Washington Post was fully familiar with CTP's frequency sharing work, including elements later central to the FAST approach, as it included a paper on CTP's PCI technology as part of its Second Progress Report, dated February 22, 1991. This was long before APC/Washington Post developed the elements of its FAST approach. CTP showed that in the Tenth Progress Report of APC/Washington Post under its Experimental License, APC/Washington Post dealt with the "rogue handset" problem with an approach seemingly copying many elements of ISCDMA.[72] CTP showed that the APC/Washington Post "algorithms," cited with approval by the Commission, to determine the "boundaries of the exclusion zones"[73] were only developed in December, 1992 or early 1993 by APC/Washington Post, more than a year after CTP had developed its own, more sophisticated algorithms.[74] Now there is new evidence. In paragraph 17 of the Order, the Commission

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[71]Dated January 27, 1993.

[72]CTP's Reply Comments in this Docket, dated March 1, 1993, page 18, footnote 64. The rogue handset problem occurs under the FAST system when a subscriber terminal is used at the top of a building (closer to microwave transmission path) rather than on the ground where APC/Washington Post has done its theoretical and field propagation measurement. Under these circumstances, APC/Washington Post would use an interference scanning approach to prevent the subscriber terminal at the top of the building from interfering with the microwave transmission. This scanning approach appears to be "borrowed" from ISCDMA,

[73]Order, paragraph 11.

[74]CTP's Reply Comments in this Docket, dated March 1, 1993. The specific algorithms for determining "boundaries for exclusion zones" cited by the Commission in paragraph 11 of the Order were only developed as part of the APC/Washington Post Tenth Progress Report, dated January 25, 1993. The algorithms, such as they are, are included as Exhibit IV of the Tenth Progress Report. These algorithms are the central part of FAST and what is utilized in the FAST system to direct the determination as to which channels are usable in a given locality and which are not. The rest of the FAST system, as described by the Commission in paragraphs 12 through 15 of the Order, is simply a methodology for taking the results of the algorithm based determination of channel usability into a data base which is in turn accessed by the base stations to allow the base stations to know which channels are available for use in their particular locality. Three points should be considered by the Commission in this regard:

describes how FAST has now been adapted for Qualcomm CDMA. Qualcomm pilot channel signal strength is used together with pilot channel scanning. Compare this to Exhibits 1 and 2 attached hereto wherein CTP's invention of frequency sharing through use of pilot channel signal strength and pilot channel scanning is described. CTP had developed what the Commission now attributes to APC/Washington Post two years before APC/ Washington Post! Again there is clear evidence that a double standard is being applied.

In its Reply Comments[75] and other filings APC/Washington Post does not even specifically deny CTP's showings that CTP preceded APC/Washington Post in use of frequency agility/dynamic channel allocation in narrow channel frequency sharing, that CTP preceded APC/Washington Post in the call set-up and monitoring procedures cited by the Commission at paragraphs 14 and 15 of its Order, and that CTP preceded APC/Washington Post in developing operating algorithms. Rather APC/Washington Post has attacked the technology of CTP, an attack which, as previously discussed, CTP has entirely rebutted. It is respectfully submitted that upon careful reading, CTP's filings provide convincing showing that many elements of FAST were derived in whole or in part from CTP's prior work. Alternatively, and perhaps more important, the filings show that major elements of the technology that the Commission feels deserves a Pioneer's Preference were developed by CTP before APC/Washington Post. If a Pioneer's Preference is to be granted for the call set-up procedures, algorithms, use of Qualcomm pilot channels and the like cited in paragraphs 11 through 15 of the Order, it should go to CTP as CTP developed these elements first.

- The algorithms developed by APC/Washington Post were not only developed more than a year later than the algorithms developed by CTP. Also, the APC/Washington Post algorithms are far less sophisticated than the CTP algorithms as can easily be seen by comparing attached Exhibits 1 and 2 to Exhibit IV of the APC/Washington Post Tenth Progress Report.

- APC/Washington Post has tested only the part of the FAST system which takes the results of algorithms and translates these results into instructions on channel usability to base stations. It has not so far as CTP can determine tested the validity of the algorithms themselves (which are set out in Exhibit IV to the Tenth Progress Report of APC/Washington Post). As the algorithms are central to FAST (what gives FAST capability to share frequency without interfering), the Commission is clearly wrong in concluding that FAST has been tested and proven out.

- Most important, as the algorithms are central to FAST, and as they weren't developed until the December, 1992/January, 1993 time frame, FAST wasn't really developed until December, 1992/ January, 1993. ISCDMA, developed in 1991 and early 1992, including the ISCDMA algorithms and all other elements, clearly has precedence over FAST. CTP was the first of all Pioneer's Preference applicants to develop a full, workable set of algorithms for frequency sharing, the central element for any frequency sharing system.

[75]APC/Washington Post Reply Comments in this Docket, dated March 1, 1993.

What CTP has lacked is the lobbying power to make the world aware of the priority of its technology. The Commission should grant CTP's Petition for Reconsideration and carefully reread the CTP filings regarding derivation of APC's technology, with particular reference to the new evidence of derivation resulting from use by APC/Washington Post of Qualcomm pilot channel monitoring. Based on this rereading, it is clear that CTP must be granted a Pioneer's Preference.

VI. THE COMMISSION'S CONCLUSIONS REGARDING CTP's WORK ON PCS INTERFACES TO FIBER OPTICS AND TO COAXIAL CABLE ARE INCORRECT ON THE RECORD. CTP SHOULD THUS BE GRANTED RECONSIDERATION AND ON RECONSIDERATION BE AWARDED A PIONEER'S PREFERENCE.

The Commission first states:

> With regard to CTP's request for a preference for its work on interfacing PCS with fiber optic and coaxial cable-based networks, we note that this was not part of CTP's original request but raised later in its filings on other applicants' requests.[76]

This is incorrect. CTP never sought a Pioneer's Preference specifically for its interface work but instead referred to its interface work as a further showing of innovation.[77] Further, CTP's interface work was not "raised later in its filings on other applicants requests" but was included as part of CTP's original filings. CTP stated as part of its original filings:

> Since 1990 CTP has also done extensive work on PCS interface with passive fiber optics and coaxial cable ("COAX"). While pioneer's preferences should be granted primarily for work on radio approaches, particularly frequency-sharing approaches, CTP's innovative work in PCS/passive fiber optic interfaces and PCS/COAX cable television interfaces should also be considered by the Commission as an enhancement of and compliment to its radio technology work that can make PCS network services a reality in the near-term. No other approach to the PCS/fiber optics interface appears to be as cost effective as the approach CTP has developed with Fulcrum, Inc., and that approach is expected to be widely adopted for situations where PCS is supplied through fiber optics. Also, the approach to carrying PCS signals in a video-occupied COAX cable developed by CTP with Digideck, Inc. appears to be the technically best, yet lowest cost proposal advanced to date. These

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[76]Order, paragraph 208.

[77]APC/Washington Post in many of its filings in this Docket similarly claimed a Pioneer's Preference not just for FAST but other work on development of PCS.

> innovations represent important CTP contributions to the transformation of PCS from a dream to a reality. CTP has expended considerable effort on their development.[78]

Next, the Commission makes a statement which clearly shows a mis-reading of CTP's filings:

> However, we find that it [CTP] has pursued the concept of cable PCS well after other entities and that its filings do not propose or demonstrate responsibility for any new or innovative concept or technology.[79]

CTP's PCS/passive fiber optics interface has nothing to do with cable TV. Fiber optics for cable TV are active, not passive. What CTP developed was technology for the telecom industry where passive fiber optics are increasingly being used, not for the cable TV industry where all fiber optics are active. No other applicant has submitted a technology to interface PCS to passive fiber optics; and as noted above, and in CTP's filings, it is passive fiber optics which will be the principal telco fiber optic transmission medium for the future in delivery of broad band services to homes and businesses.[80]

With regard to COAX, again CTP did not pursue "cable PCS" as the Commission states. Rather CTP has led in development of a technology allowing transmission of PCS in a fully channel occupied cable TV system, so called Microchannel™ technology.

With regard to the Commission statement that no "new or innovative concept or technology" is involved, basic elements of both the technology for the PCS/passive fiber optics interface and COAX interface are patented. There can be no justification for the Commission to conclude that patented technology is not innovative.

CTP's Petition for Rehearing should be granted so that the Commission can carefully consider CTP's interface work in so far as it bears on CTP's innovation for the PCS industry. Based on this innovation, as well as ISCDMA, a Pioneer's Preference should be awarded to CTP.

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[78]CTP Reply Comments in this Docket, dated June 25, 1992, pages 5, 6.

[79]Order, paragraph 208.

[80]David Reed, OPP Working Paper Series, Putting It All Together: The Cost Structure of Personal Communications Services, page 14, notes the advantage of passive fiber optics for delivery of PCS.

CONCLUSION

CTP, a very small business indeed compared to APC/Washington Post, Cox and Omnipoint, has exhausted its resources in developing PCS and PCS technologies, and helping start the PCS industry. Now it finds itself given very short shrift. In many instances in the Order, the Commission has so misconstrued CTP's filings that it appears the Commission is trying to find excuses not to award a Pioneer's Preference to CTP while awarding a Pioneer's Preference to APC/Washington Post. The arguments of APC/ Washington Post are cited and given weight in the Order while the stronger, countervailing arguments of CTP are ignored and not cited. The Commission Rules are changed to require testing, favoring larger businesses which can afford extensive testing. The technology description of the APC/Washington Post FAST system set forth in paragraphs 11 to 15 of the Order is in many elements an exact description of CTP's technology, only CTP developed and publicly identified these elements much earlier than APC/Washington Post. It is all most discouraging. One does not like to believe that the power of the Washington Post, and the numerous ex parte contacts that have occurred have influenced matters. One does not like to believe that the Commission is favoring large businesses with power, influence and money to spend over entrepreneurial small businesses. Yet if one steps aside and carefully reads CTP's filing (not as artful as APC's but truthful), one must conclude CTP has been at least as innovative as APC/Washington Post and is as deserving of a Pioneer's Preference.

Throughout this proceeding, CTP has never said APC/Washington Post should be denied a Pioneer's Preference. We don't say so now. What should be done is that provision should be made in the Pioneer's Preference process for small businesses like CTP. Small businesses shouldn't be shut out because they don't have the money for extensive public testing, high power lawyers or Washington lobbying.

The record clearly shows that CTP is deserving of a Pioneer's Preference because of its technology innovation and many firsts in the industry. CTP's Petition for Reconsideration should accordingly be granted and a Pioneer's Preference awarded to CTP. At least as many small businesses should be granted Pioneer's Preferences as have now been granted to large businesses, and CTP should be one of the small businesses granted a Pioneer's Preference. These preferences should be in the BTA bands, leaving MTA bands for larger business.

Respectfully submitted,

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EXHIBIT 1

Co-Existence of Personal Communication Systems with Fixed Operational Microwave Links Using Interference Sensing Code Division Multiple Access (ISCDMA) Technology

prepared for

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Appendix A A general discussion of Rules and Regulations that are essential to the design of Personal Communication Systems in the 1850-1990 MHz band

Appendix B Proposed Rules and Regulations for Personal Communication Systems in the 1850-1990 MHz band

Appendix C Extracts from Part 94 of Rules and Regulations of FCC

Appendix D Important C/I Tables from Document TSB-10E

Co-Existence of Personal Communication Systems with Fixed Operational Microwave Links Using Interference Sensing Code Division Multiple Access (ISCDMA) Technology

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1.0 Abstract

This paper presents the theory of a novel approach to Personal Communication Systems (PCS) that uses the interference sensing capabilities of CDMA pilot channels with CDMA paging channels. We show that Interference Sensing Code Division Multiple Access technology (ISCDMA) is capable of providing interference protection for fixed microwave users while maintaining good communication quality in the ISCDMA system. Various advantages which ISCDMA offers for rapid deployment of PCS are given, as well.

2.0 Introduction

Interference Sensing Code Division Multiple Access[1] (ISCDMA) is a method that combines an interference sensing approach and spread spectrum techniques to solve the co-existence problem of Personal Communication Systems (PCS) and existing fixed microwave links. Various investigations by different companies and research groups [1], [2], [3] have shown that there is enough spectrum for initial operation of PCS without reallocating fixed microwave links to other frequencies[2]. One important difference between the ISCDMA technology and approaches proposed by other companies is that ISCDMA will actively provide interference protection for fixed microwave users while other approaches depend passively on the careful engineering of exclusion zones, those zones in which a PCS base station could interfere with the received signal on microwave

1. ISCDMA technology is being pursued by Corporate Technology Partners (CTP). The concept of ISCDMA is described in CTP's Pioneer Preference application submitted to FCC [17], [18].

2. Federal Communications Commission's Notice of Proposed Rule Making (NPRM) [16] suggests to divide the spectrum into three blocks for licensed PCS applications. The tentative frequency allocation and proposed rules for PCS are shown in Appendix B of this report.

links. Moreover, if ISCDMA is employed for PCS systems, the portable handset can be designed for use in any city in the country, making ISCDMA attractive for emerging Personal Communication Systems. In order to show that ISCDMA technology is feasible to implement, the protection of interference from the PCS system to fixed microwave users must be guaranteed. Analysis that describes a way to provide such protection using CDMA pilot channels and paging channels is presented in this paper.

Equipment implementing Qualcomm's Direct Sequence Code Division Multiple Access technology (DSCDMA) is assumed in our analysis. Frequency division is employed by dividing the available spectrum into nominal 1.228 MHz wide channels[4]. Qualcomm's technology provides four different sub-channels in each 1.23 MHz wide forward channel[4]. They are traffic channels, the synchronization channel, paging channels and the pilot channel. The pilot channel is used by the mobile to identify the base station which provides the best signal (that is the strongest and the lowest bit-error rate signal) at the mobile. The pilot channel is also used for phase tracking, for power control in both directions, as well as for power allocation in the forward link[5]. As explained subsequently, the pilot channel can also be readily used in the ISCDMA system for interference sensing. In fact, very little modification of the Qualcomm technology is required for ISCDMA to apply. Coherent detection and non-coherent detection are used at the mobile and at the base station, respectively. More specifications on Qualcomm's DSCDMA can be found in references [4], [5] and other Qualcomm publications.

Most standard fixed operational microwave links have the transmit and receive frequency offset by 80MHz[2]. While reference [2] shows that some non-standard microwave links[3] exist in some cities, research in [2] finds that the highest number of non-standard microwave links found in any of the eleven largest U.S. cellular markets is only 6[4]. Therefore, we concentrate on a feasibility analysis for an ISCDMA system for the standard two-way transmission microwave links. In Section 3.0, the interference level from a single PCS two-way transmission link to a single microwave link is presented. In Section 3.1, this analysis is expanded into the general case of many base stations and many mobiles. Interference sensing using pilot channels and paging channels for the ISCDMA system is demonstrated in Section 3.2. Both references [1] and [2] show that it is common for more than one microwave link to operate at the same frequencies[5] in different parts of a city. The effects of multiple microwave links using the same frequencies on the ISCDMA system are presented in Section 4.0. Interference computation schemes in this report have followed basic rules proposed in Appendix F of FCC's Notice of Proposed Rule Making (NPRM) [16]. Numerous advantages of ISCDMA for PCS are presented in Sections 5.1-5.8.

3. either simplex or not following standard channel plan. Standard channel plan is shown in Appendix C of this paper.

4. Los Angeles

5. reverse channel and forward channel

3.0 Two-Way Transmission Microwave Link with One Base Station and One Mobile

Figure 1 shows a general interference situation between a PCS system and fixed microwave stations. In the figure, BS represents a PCS base station and MICRO represents a microwave tower. In general, there will be more than one microwave link and more than one base station and mobile in any regional area. In this section, we will study the coupling of energy between the microwave link and the PCS system with the most simple form, i.e. a single two-way transmission link in each system. We can then expand the analysis to more general cases.

In Figure 1, microwave station A transmits frequency f1 and receives frequency f2 while microwave station B transmits frequency f2 and receives frequency f1. For the PCS system, the base station transmits frequency f1 and receives frequency f2 while the mobile transmits frequency f2 and receives frequency f1[6]. The difference between f1 and f2 for standard two way microwave links is 80 MHz. Thus, the difference between the transmit and receive frequencies of PCS has been suggested to be 80MHz in order to simplify interference analysis [16]. We conclude that 80 MHz separation is most prudent, as it is possible to fabricate duplexers for this frequency range, and PCS system design is relatively easy with 80 MHz offset. As shown in Figure 1, four sources of interference between the PCS system and the microwave link are possible.

- Interference from Microwave Station A to the mobile $I_{A/mobile}$
- Interference from Microwave Station B to the base station $I_{B/BS}$
- Interference from the mobile to Microwave Station A $I_{mobile/A}$
- Interference from the base station to Microwave Station B $I_{BS/B}$

If there are many base stations and many mobiles in the system, there will be additional interference to the microwave link as well as within the PCS system. This will be discussed later. For the present discussion, we assume there is only one mobile and one base station in the PCS system. For the ISCDMA system, the base station can scan the entire frequency band and measure the interference power from the microwave station B[7], $I_{B/BS}$, and if the maximum transmitter power of the microwave station B is known, then the path loss from microwave station B to the base station can be calculated from the measured signal level from the microwave tower:

$$I_{B/BS}(dB) = Pt(B) - PL_{B/BS} + G_B + G_{BS} \tag{EQ 1}$$

6. Alternatively, the base station can transmit frequency f2 and receive frequency f1 while the mobile transmits frequency f1 and receives frequency f2. In order to provide maximum isolation between the PCS system and the microwave link, the base station and the mobile should transmit at frequencies that have minimum mutual interference between the PCS system and microwave users. In Figure 1, we assume that $I_{A/BS}$ is larger than $I_{B/BS}$.

7. The base station also measures the interference from the microwave station A. For the above discussion, we assume $I_{B/BS}$ is smaller than $I_{A/BS}$ and therefore the base station decides to transmit frequency f1 rather than frequency f2.

where $Pt(B)$ is the power transmitted by microwave station B, $PL_{B/BS}$ is the measured path loss from microwave station B to the base station. Symbols G_B and G_{BS} are the antenna gains of microwave station B and the base station, respectively. It should be noted that $I_{B/BS}$ is based on the known characteristics of the microwave transmitter and is a static quantity, subject to small changes due to measured signal strength. All values in equation (1) are decibel (dB) values.

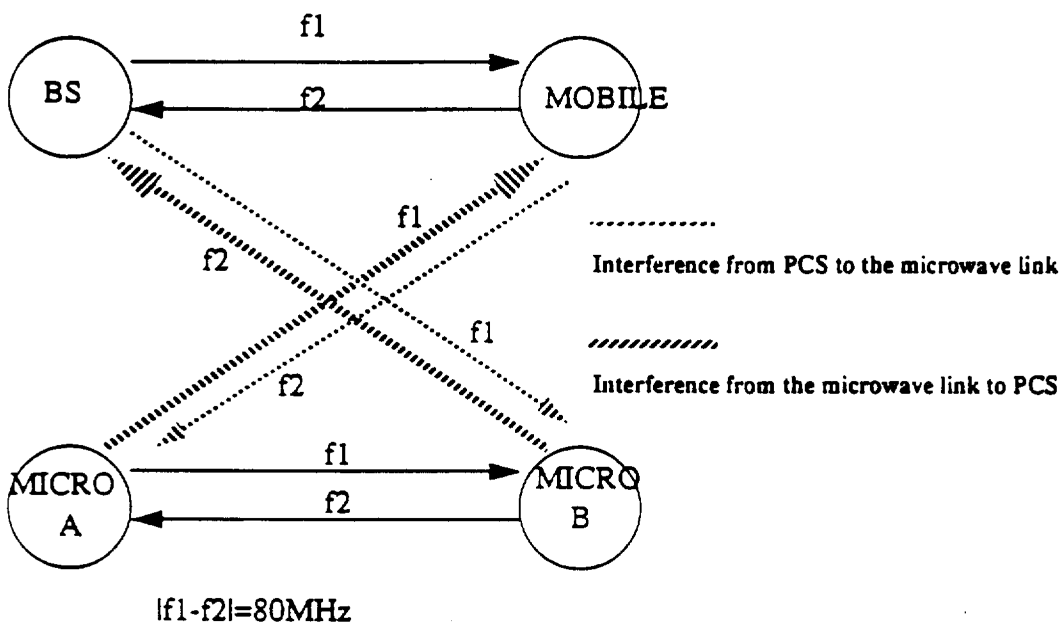

FIGURE 1. Mutual Interference of Microwave Link (two way transmission) and PCS system

If PCS channels are assumed to be reciprocal[8] and f1/f2 is close to unity, then the path loss from the microwave station B to the base station is virtually the same as that from the base station to the microwave station B. If the transmitter power of the base station is known, the corresponding average interference power from the base station to the microwave station is given by:

8. It is well known that path loss in urban propagation channels is characterized by a log-normal large scale path loss superimposed by small scale fading[10]. While large scale path loss is not sensitive to small frequency change, small scale fading of a narrow band signal is extremely sensitive to frequency change because it is primarily a phenomenon of superposition of multipath components with different amplitudes and phases, which can change significantly even if the frequency changes by a small amount. However, references [8] and [9] show that rms delay spreads in microcellular propagation environment vary from a few hundred nanoseconds to a few microseconds, depending on the location, the T-R separation and other factors. Assuming a rms delay spread value of 500 ns, which corresponds to a coherence bandwidth of about 200kHz[10], a 1.25 MHz bandwidth can therefore offer frequency diversity. This frequency diversity implies that the power received over the wide bandwidth changes little over time or space. Thus, it is reasonable to assume the path loss between the base station and the microwave station is reciprocal for "wideband" spread spectrum even though frequencies are offset by 80MHz.

$$I_{BS/B}(dB) = I_{B/BS} - Pt(B) + Pt(BS) \quad \text{(EQ 2)}$$

where *Pt(BS)* is the power transmitted by the base station and all values are in decibels. Note that equation (2) is based on the assumption that transmitter and receiver antenna gains are the same at the microwave tower or the PCS station. Under such conditions, actual antenna gains need not be known in order to measure interference.

It is desirable to have the interference power level from the PCS system to the microwave links to be small. One standard is that the interference power received by the microwave receiver should be 6 dB below the operating noise level[7], [16]. The maximum tolerable interference threshold for microwave station B is denoted as Th_B. The standard criteria for interference protection of microwave links are based on Part 94 of the FCC's Rules and Regulations [20] and EIA's document TSB-10E [19]. Important extracts from Part 94 and TSB-10E are given in Appendices C and D of this report. In order to protect the microwave link from interference caused by the PCS system, the following inequality must be satisfied:

$$I_{B/BS}(dB) \le Th_B + Pt(B) - Pt(BS) \quad \text{(EQ 3)}$$

If the base station determines that equation (3) is satisfied, it can transmit frequency f1 without interfering with microwave station B. The mobile then needs to determine whether the interference from microwave station A is small enough to protect microwave station A from interference while maintaining good communications quality in the PCS system. The figure of merit for determining the quality of transmission of a CDMA signal is the bit energy to noise density ratio (*Eb/No*). The *Eb/No* at the mobile is given by:

$$\left(\frac{E_b}{N_o}\right)_{mobile} = \frac{Pr_{mobile}/R}{(I_{A/mobile} + \eta)/W} = \frac{Pr_{mobile} \bullet PG}{I_{A/mobile} + \eta} \quad \text{(EQ 4)}$$

where *PG* is the processing gain[9], *R* is the bit rate, *W* is the spreading bandwidth, and η is thermal noise power[10]. The power of the desired signal received at the mobile, which is a function of transmitter power of the base station, location of the mobile, and the propagation, is given by Pr_{mobile}. It is clear from equation (4) that if $I_{A/mobile}$ is much larger than Pr_{mobile}, the communication quality at the mobile may not be acceptable.

The interference power $I_{A/mobile}$ is measured at the mobile. The methodology to measure $I_{A/mobile}$ by pilot channels will be presented in Section 3.2. Similar to the above derivation, microwave station A is protected from interference caused by the PCS subscriber if the following inequality is satisfied.

$$I_{A/mobile}(dB) \le Th_A + Pt(A) - Pt(mobile) \quad \text{(EQ 5)}$$

9. A bit rate of 8kb/s is that of an acceptable toll quality vocoder which gives processing gain, PG, to be equal to 154 [4].

10. Thermal noise power is equal to the thermal noise spectral density (η_o) multiplied by the total spreading bandwidth W, in this case 1.23MHz for Qualcomm equipment.

Equations (3) and (5) guarantee protection of microwave users from interference caused by PCS base stations and mobiles. The measured interference powers from the microwave station B to the base station and from microwave station A to the mobile are used in equations (3) and (5) to determine if the interference from the PCS system to the microwave link is below the thresholds Th_A and Th_B.

Horizontal polarization is used for half of the microwave links [3] while vertical polarization is likely to be used in PCS systems. The polarization mismatch of the two systems can provide extra protection for microwave users. However, we cannot rely on polarization to provide sufficient isolation between the two systems because depolarization of electromagnetic waves in a non-line-of-sight channel is generally high. If polarization effects are assumed to be identical on forward and reverse links, equations (2) to (5) can be applied without modification. It is likely that reciprocity of the depolarization effects holds, though we are not aware of measurements that confirm the consistency of polarization effects over an 80MHz bandwidth with center frequency around 1900 MHz.

3.1 Multiple Base Stations and Multiple Mobiles

If there is more than one mobile and more than one base station transmitting frequency f1 and receiving frequency f2 in the area of interest, then the interference power from the PCS system to the microwave system will definitely be higher than obtained in the single base station/single mobile case. The interference level within the PCS system will be higher, as well. The summed power of the PCS transmission[11] at the base station can increase as subscriber demand increases, causing increasing interference to the microwave users, whereas this would not occur in "normal" demand load operation. The interaction between multiple base stations with multiple mobiles and a single two-way microwave link is considered in this section. By repeating the same argument for different microwave links, the capacity and performance of the ISCDMA system can be obtained.

Assume there are N mobiles that transmit frequency f2 and receive f1 within the area of interest, and there are M base stations in the area. According to the FCC's NPRM, the total interference power from PCS base stations to microwave station B is equal to the summation of interference power of each base station. The theoretical interference analysis for multiple base stations and mobiles is considered in this section while the actual implementation algorithm is proposed in the next section. As shown in the next section, intelligence to perform interference analysis is implemented at PCS base stations and mobiles. The total interference power (in absolute scale, not dB scale) from the PCS mobiles to the microwave station A, $I_{PCS\text{-}mobiles/A}$, can be given by:

11. The summed power of transmission of a CDMA channel includes transmission powers of the pilot channel, the synchronization channel, paging channels and traffic channels. Since the transmission power for the traffic channels depends on subscriber demand, the total transmission power of a CDMA channel is also a function of traffic density. Hence, it is possible that interference power from PCS base stations to the microwave station can be higher in peak hours where subscriber demand is high.

$$I_{PCS-mobiles/A} = \left(\sum_{i=1}^{N} \frac{I_{A/M_i} Pt(M_i)}{Pt(A)}\right) \frac{BW}{1.23} \le Th_A \qquad \text{(EQ 6)}$$

where $I_{A/Mi}$ is the interference power (absolute scale) from the microwave station A to the i-th mobile and $Pt(M_i)$ is the power transmitted by the i-th mobile. It should be noted that the interference to the microwave station is multiplied by a factor[12] of $BW/1.23$, where BW is the operating receiver bandwidth(MHz) of the microwave station A and 1.23 denotes the bandwidth of the Qualcomm CDMA signal.

Similarly, the total interference (in absolute scale) from the PCS base stations to the microwave station B, $I_{PCS\text{-}basestations/B}$, is given by equation (7).

$$I_{PCS-basestations/B} = \left(\sum_{i=1}^{M} \frac{I_{B/BS_i} Pt(BS_i)}{Pt(B)}\right) \frac{BW}{1.23} \le Th_B \qquad \text{(EQ 7)}$$

where $I_{B/BSi}$ is the interference power from the microwave station B to the i-th base station and $Pt(BS_i)$ is the power transmitted by the i-th base station[13]. Interference measurement from the microwave station B to each base station can be made prior to the operation of the PCS system and updated on a regular basis. The coordination distance proposed by the FCC depends on the antenna height and the transmitter power of PCS base stations. The proposed coordination distances are shown in Appendix B of this paper. It is necessary to include all microwave stations that are within the coordination distance into PCS design considerations. Therefore, to keep track of the total interference from the PCS system to the microwave link, each base station must store the interference power from microwave station B to each base station, the transmitter power of the microwave station, and its operating bandwidth. Also, the difference between Th_A and $I_{PCS\text{-}mobiles/A}$ and the difference between Th_B and $I_{PCS\text{-}basestations/B}$ should always be *larger* than zero to avoid interference with microwave stations A and B. Finally, the difference between Th_A and $I_{PCS\text{-}mobiles/A}$ should be passed to each mobile over the paging channels to allow each mobile to compute the interference margin it would have if it were to transmit on that particular frequency. Additional means for keeping track of the total interference from the PCS to the microwave link are presented in the next section.

Hence, in order to provide protection for the microwave system, $I_{PCS\text{-}mobiles/A}$ and $I_{PCS\text{-}basestations/B}$ must be less than the required thresholds. Every time a new call setup is requested, the interference power from the PCS system to the microwave link must be

12. There is more than one CDMA reverse channel within the operating bandwidth of microwave station A. The total interference power from the PCS system to the microwave station A includes interference power from all reverse channels within the operating bandwidth of the microwave station A. In equation (6), we assume the interference power caused by each reverse channel is the same, although this can be easily extended into a more exact expression using knowledge of the CDMA channel of each mobile.

13. $Pt(BS_i)$ is the power transmitted by the base station i for one forward channel only. In equation (7), we assume $Pt(BS_i)$ for all forward channels within the operating bandwidth of the microwave station B are the same. For example, if the operating bandwidth of the microwave link is 5 MHz, there will be four PCS forward channels causing interference to that microwave link.

calculated and the new interference level should always be lower than the threshold. Similarly, every time a call is completed, the interference power must be updated as well. However, while the two inequalities[14] in equations (6) and (7) ensure that the PCS system will not interfere with the microwave users, they are not sufficient to ensure frequencies f1 and f2 are good for operation within the PCS system, because interference power from the microwave link to the PCS system may be too high for the PCS system to have good communication quality. The *Eb/No* values for PCS reverse and forward links must be better than a certain performance level, $(Eb/No)_{system}$, in order to provide a certain bit-error-rate (BER) performance.

Consider the reverse link again (from the mobile to the base station). If perfect power control is assumed on the reverse link, then the bit energy to the noise density level[15] at base station *j*, $(Eb/No)_{BSj}$, is given by[16] [5]:

$$\left(\frac{E_b}{N_o}\right)_{BS_j} = \frac{P_{R_j} \bullet PG}{(N'-1)\,P_{R_j} + I_{B/BS_j} + I_{out} + \eta} \leq \left(\frac{E_b}{N_o}\right)_{system} \qquad \text{(EQ 8)}$$

where N' is the number of mobiles within the cell of interest, PG is the processing gain, I_{out} is interference power due to mobiles that are outside the cell, $(Eb/No)_{system}$[17] is the minimum system performance required, and P_{Rj} is the power received at the base station *j* due to each mobile with prefect power control. Qualcomm has verified the transmission quality of CDMA signals through extensive field trials, and hence the implementation of equation (8) has been demonstrated empirically[18]. Equation (8) can also be used to study capacity of ISCDMA system.

The ratio between the in-cell noise to total received noise, not including the microwave interference power, is known as the frequency re-use factor[6]. Some analysis of the frequency re-use factor is presented in [6]. However, the results of [6] are not directly applicable to the ISCDMA system[19]. The geometrical analysis technique[20] in [6] could be applied to study the effects of the fixed microwave link on the frequency reuse factor. If the power received at the base station due to each mobile within the cell, the maximum allowable transmitter power by each base station,[21] and the interference

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14. $I_{PCS/A} \leq Th_A \qquad I_{PCS/B} \leq Th_B$

15. The bit error rate (BER) performance, which can be measured at the base station and the mobile, is a function of (Eb/No). By measuring BER, we can obtain a reasonable estimate of (Eb/No) if the modulation characteristics are known.

16. Voice activity gain and sectorization gain are ignored to simplify analysis

17. 5dB to 7dB according to reference [5]

18. Equation (8) is embedded inside Qualcomm's system already.

19. More users, operating at the same frequency as the microwave station, are allowed in locations far from the microwave station in ISCDMA. In other words, the allowed number of users, based on interference threshold of the microwave station, increases as the distance between users and the microwave station increases. The results of [6] can be modified to study the capacity of ISCDMA system in a spectrum sharing environment by including a density factor on the users and locations of the microwave stations.

20. Reference [6] used a concentric circle geometry instead of a conventional hexagonal cell geometry to facilitate analysis.

power from microwave station B are known, then the maximum number of allowable users in each cell[22] can be computed from equation (8).

If P_{Rj} is very large compared to $I_{B/BSj}$, then the effect of interference from the microwave station B to the PCS system on the bit energy to noise density ratio at the base station can be ignored. However, increasing P_{Rj} will increase interference on microwave station A due to the mobiles since P_{Rj} and $Pt(M_i)$ are related by the following equation:

$$P_{R_j}(dB) = Pt(M_i) - PL_i \qquad \text{(EQ 9)}$$

where PL_i is the propagation loss (absorbing antenna gains into the term) between the i-th mobile (i=1,2,.. , N') and base station j. An appropriate value of P_{Rj} can be computed such that the interference on the microwave link is tolerable while the capacity of the system is maximized[23].

Equation (8) ensures the signal quality at the base station (reverse link) is better than the minimum tolerable quality, and together with equation (6), confirms frequency f2 at the reverse link will not cause excessive interference to microwave station A while maintaining acceptable transmission quality.

Next, consider the forward link, that is, from the base station to the mobile. The mobile can determine the strongest pilot channel and measure its *Eb/No* ratio. From the pilot channel measurement, the quality of the PCS forward traffic channel, if it is acquired, can be determined as follows. The *Eb/No* value of the pilot channel should be above a certain level in order to maintain a good transmission quality for the PCS forward link. First, the *Eb/No* ratio of the pilot channel of base station i at the j-th mobile, $(Eb/No)_{pilot_{i,j}}$, is lower bounded by[5]:

$$\left(\frac{E_b}{N_o}\right)_{pilot_{i,j}} \geq \frac{(1-\beta)Pr_{i,j} \bullet PG}{\left(\sum_{i=1}^{M} Pr_{i,j}\right) + I_{A/M_j} + \eta} \qquad \text{(EQ 10)}$$

where β is the fraction of the maximum transmitter power which is devoted to the subscribers (1-β is the fractional power devoted to the pilot and does not vary with traffic) and $Pr_{i,j}$ is the power received at the j-th mobile due to the i-th (i=1,2, ..,M) base station.

The *Eb/No* ratio of the information bearing channel at the j-th mobile communicating with the i-th base station is lower bounded by [5]:

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21. The maximum allowable base station transmitter power depends on the interference power from the microwave station B to that base station. A way to compute the maximum allowable power is presented in the next section, and is based on equation (7).

22. The maximum allowable users in each cell should be different. Cells far away from a microwave link should allow more users than cells close to a microwave link.

23. We do not address the algorithm for setting P_{Rj} in this report. However, we note that the value P_{Rj} will determine the coverage area of a cell and the interference levels to adjacent cells and microwave users.

$$\left(\frac{E_b}{N_o}\right)_{mobile_{i,j}} \geq \frac{\beta\Phi_{i,j}Pr_{i,j} \bullet PG}{\left(\sum_{i=1}^{M} Pr_{i,j}\right) + I_{A/M_j} + \eta} \geq \left(\frac{E_b}{N_o}\right)_{system} \quad \text{(EQ 11)}$$

where $\Phi_{i,j}$ is the portion of the power devoted to the subscriber of interest, and $\sum_{j=1}^{N} \Phi_{i,j} \leq 1$ for any one of the j base stations. Combining equations (10) and (11), we have the following ratio:

$$\frac{(E_b/N_o)_{pilot_{i,j}}}{(E_b/N_o)_{mobile_{i,j}}} = \frac{1-\beta}{\beta\Phi_{i,j}} \quad \text{(EQ 12)}$$

Equation (12) relates the bit energy to noise density ratio of the pilot channel to that of the forward traffic channel. Hence, a threshold that incorporates equation (12) can be designed at the mobile to reject an unusable forward channel (e.g. a channel which has an *Eb/No* value below the threshold in equation (11)). The mobile receiver scans through all pilot channels. If the first pilot channel has low power or exhibits bit error transmission problems, the subscriber terminal continues the scan until it finds a pilot channel with strong power and low bit error rate. However, these are not sufficient criteria for selection of the traffic channel because the interference from the PCS system to the microwave link may be high. Equations (6), (7), (8) and (11) must be satisfied *simultaneously* if a frequency pair f1/f2 is functional in the PCS system while the interference to the microwave station is tolerable. The pilot channel and paging channel are used to satisfy these four requirements, as discussed in the next section.

3.2 Interference Sensing by Pilot Channels

The criteria for determination of "tolerable" interference caused by PCS on microwave users were derived in equations (6) and (7). The transmission quality at the mobile and at the base station were derived in equations (8) and (11). Four criteria must be satisfied if a duplex CDMA channel is to be deemed *usable* for communication between the base station and the mobile:

1. total interference from PCS to the microwave station A is below threshold
2. total interference from PCS to the microwave station B is below threshold
3. transmission quality of the forward link of PCS is above a particular performance level
4. transmission quality of the reverse link of PCS is above a particular performance level

First consider the forward link, i.e. from the base station to the mobile. We have demonstrated that the total interference from the PCS system to the microwave station B is given by equation (7). Therefore, if interference received by microwave station B from each PCS base station is less than *Th/M*, where *M* is the total number of base stations, then the total interference from the PCS system to the microwave station B is less than the threshold and satisfies the second criterion above. If the maximum allowable PCS transmitter power at a particular base station is less than the minimum power to set-up a traffic channel[24] usable over the desired coverage area, then the base station considers the forward channel *unusable* in that cell. Other CDMA forward channels operating at other frequencies may still be usable. Suppose the channel is unusable for the forward link in L cells[25], the maximum allowable transmitter power[26] by each base station is given by:

$$Pt(BS_i) \le \frac{Th_B Pt(B)}{(M-L)\, I_{B/BS_i}} \qquad \text{(EQ 13)}$$

The maximum allowable transmitter power of the base station is large if the interference caused by microwave station B onto that base station is small, and vice versa. The total allowable PCS base station transmitter power includes power for all forward channels, i.e., traffic channels, pilot channels, synchronization channels and paging channels, that are within the operating bandwidth of the microwave link. Equation (13) provides one way to divide the allowable transmitter power of base stations by making interference powers from each base station to the microwave station B the same. If there are high demands in one particular cell, the allowable transmitter power of that base station can be increased by decreasing the maximum allowable power in cells with less demand. The total interference power to the microwave station is below the specified threshold as long as equation (7) is satisfied.

Each base station first needs to follow two steps to determine if the forward traffic channel, with a request for an additional mobile, is still usable or not. As a first step, the base station should estimate the total interference to the microwave station B if an additional mobile is put into the cell. If the total interference of the PCS forward link to microwave station B (which is increased by an extra mobile in the cell) is still below the threshold and the additional user does not cause a degradation of transmission quality of the PCS reverse link to fall below a certain performance level, then the forward traffic channel, with an additional mobile, is still usable. If one or both conditions are violated, the base station should indicate to the mobile[27] that the forward traffic channel is not available. To sum up, the following two criteria must be satisfied simultaneously if the PCS forward traffic channel, with an additional mobile, is to be usable.

- the total interference by the forward link of the PCS system onto the microwave station B, with the additional interference caused by the extra user, is still within the required threshold
- the transmission quality of the reverse link, with the additional mobile, will be above the specified performance level

24. The minimum power to set-up a traffic channel includes power for each of the pilot channel, the synchronization channel, the paging channel, and the traffic channel.[4]

25. L, I_{B/BS_i} are fixed quantities

26. Include power of all forward channels within the operating bandwidth of microwave station B of each base station

27. One way to do this is to embed the information into the paging channel.